Platinum-RTD Heat-Prober™ Thermometer

INSTRUCTION MANUAL

MODELS
392M, 392MX and 360X

Wahl

WAHL INSTRUMENTS, INC. 5750 HANNUM AVE.
CULVER CITY, CALIFORNIA 90230

W392M 11/81
REV. D 6/85

WARRANTY

Wahl Instruments Corporation hereinafter referred to as the Corporation, warrants each instrument of its manufacture to be free from defects in material and workmanship under normal use and service for one year from the date of shipment. If our examination discloses that malfunction was caused by either poor workmanship or defective material, the Corporation will repair or replace the components accordingly, providing these were forwarded to the factory within one year from the date of shipment, properly packaged and transportation prepaid. The Corporation assumes no liability for damages of any kind, direct or indirect, as a result of the installation and/or use of the equipment. The purchaser by accepting the equipment will assume all liability for any damages, direct or consequential, to himself, his employees, agents or others, which may result from use or misuse of this equipment.

The above warranty also applies to instrument accessories manufactured by the Corporation except probes, which, due to the environmental nature of their use, cannot be replaced unless returned unused. In addition, the Corporation assumes no liability for any costs resulting from removing and reinstalling any of its product for replacement under the terms of the above warranty.

Warranty Card must be filled in and returned for above warranty to be valid.

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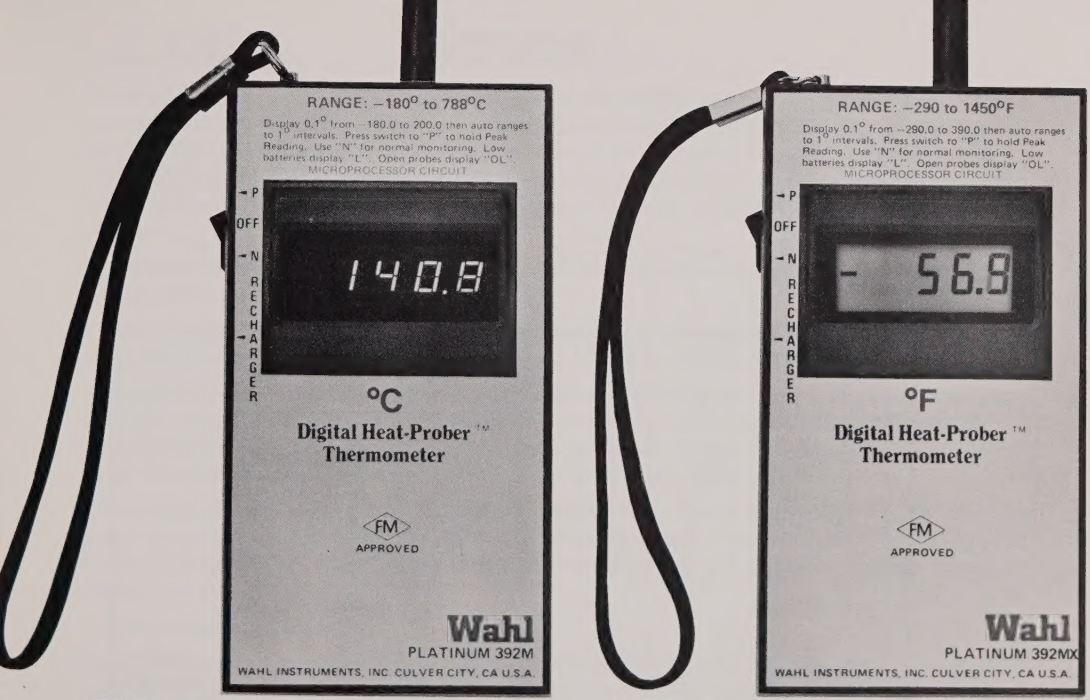

LED Display **LCD Display**

Figure 1-1. Microprocessor Based Platinum Resistance Thermometer

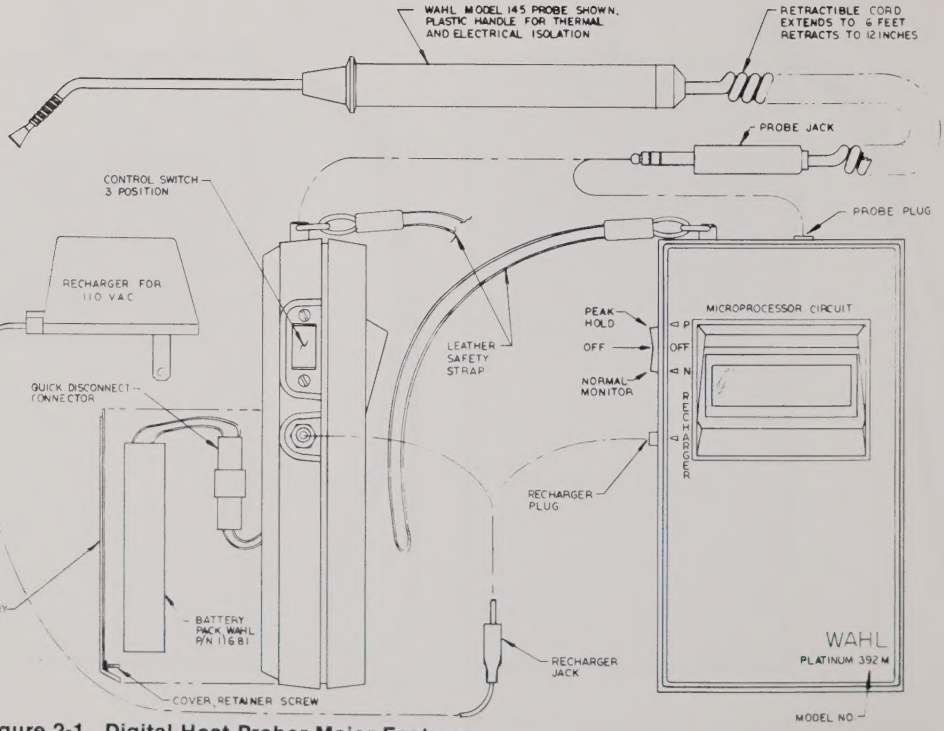

Figure 2-1. Digital Heat Prober Major Features

1.0 INTRODUCTION

The Digital HEAT-PROBER R[1] is the most modern instrument for measuring temperature. It uses the latest microprocessor technology to provide complete tracing of platinum resistance curve to 0.1°F conformity. It provides the certainty of digital display and the precision of 0.1° increments. HEAT-PROBER R is a complete instrument with its own rechargeable battery power supply and recharger, and a group of interchangeable probes[2] designed for rapid and accurate temperature measurement.

The probes and meters are individually calibrated and then tested together in temperature baths before being sent to the user.

The LED display is 0.3" tall and has a high brightness for good readability in all light conditions. To minimize power drain, the display is multiplexed. The LCD display is 0.4" high.

A large portion of the circuit is designed with low power C-MOS components. The result is a design which provides a low power drain operation, which allows operation on rechargeable batteries for a continuous 6-hour period or more. Continuous operation is also possible with the recharger attached. In both cases, the instrument is powered from the batteries.

The instrument contains as a standard, the unique Wahl "Maxi Temp" digital peak hold circuit which gives the user the option to hold the highest temperature sensed. The peak-hold circuit is achieved by the microprocessor scanning the probe input temperature to determine the peak versus an analog circuit.

1.1 Qualification Tests

This instrument has been extensively tested under temperature environments from −40 to +140°F, subjected to 4-foot drop tests, battery life test and running life tests.

[1] Made under U.S. Patent No. 4,050,309, issued to Wahl Instruments.

[2] Patent Pending.

Mean time between failure is based on using preburned-in C-MOS electronic components and is rated at 4000 hours.

1.2 Hazardous Location Operation

The instrument is Factory Mutual approved for hazardous location operation and carries the FM label as standard. Factory Mutual approval as intrinsically safe for hazardous location operations is in the following categories: Class I and II, Division I, Group D, F, and G when used with battery pack P/N 11681-1. A higher level of approval for Group C, D, E, F, and G is also available as the –S option, and uses a battery pack, P/N 11681-2, which contains, in addition, a current limiting fusible resistor.

2.0 TO OPERATE (See Figure 2-1)

Insert probe into jack at front. Turn on the switch at the left. The switch is 3-position; the lower detent is marked "N" for normal temperature monitoring, the middle detent is "OFF" and the upper detent is marked "P" for use of the Wahl "Maxi Temp" peak hold circuit. This will track temperature and hold the highest attained reading. The room temperature should be displayed in °C or °F as indicated. If "L" appears or if there is no reading, this indicates the battery is discharged. Recharge the unit by inserting the recharger in a 110 VAC, 50-60 Hz wall outlet and plug in the recharger jack to the instrument socket on the left. (Turn the instrument switch OFF during recharging, as this will draw current for the display. Charge for 6-7 hours)*. Turn on instrument again.

Make measurements with sensor probe as required. Turn off switch when measurements are complete to preserve battery life.

2.1 Meter Operation

The HEAT-PROBER instrument has an accurate measuring range as stated on the front label from –180°C to 788°C (or –290°F to 1450°F). The probes, however, may not be capable of this entire range of use. Wahl probes are typically capable of –50°C to 500°C (or –50°F to 900°F).

*(Special Note on Care of Rechargeable Batteries, See Paragraph 2.4.)

The digital readout will show 0.1° increments from −180.0°C to +190°C (or −290°F to 375°F). At approximately 190°C (or 375°F) the instrument automatically ranges to single degree C or F increments. When returning from higher temperatures to below 190°C (or 375°F), the instrument will automatically begin to read in 0.1° increments again.

The increase in read-out increments to 1°C or F is done to be consistent with accuracy capability of the sensor instrument in the higher temperature ranges where 0.1 increments are not significant.

2.2 Automatic Polarity

When the temperature sensed is below zero, a minus sign will automatically show on the digital display. Absence of a sign indicates positive temperature.

2.3 Digital Display and Accuracy

The characteristic of digital readouts is a flicker in the least significant digit. In this instrument, you can expect to see a 1-digit flicker, particularly when reading 0.1 increments. Variations over ±0.1 will be attributable to sensor temperature changes.

2.4 The Batteries

The HEAT-PROBER is powered with five size AA rechargeable nickel-cadmium batteries, 1.25 volt each. The total capacity is 450 milliampere hours at 6.0 volts. The display demands the largest power drain. Depending on the number of digits being displayed, the batteries can power the instrument for a minimum of 5 hours or for as long as 6 hours.

It is possible to use 9 volt alkaline transistor radio-type batteries to power the 392M meter. The instrument has a voltage regulation which will accept and control the power from a 9 volt battery. Battery life is approximately 3 hours continuous for the LED, and 6 hours for the LCD read out.

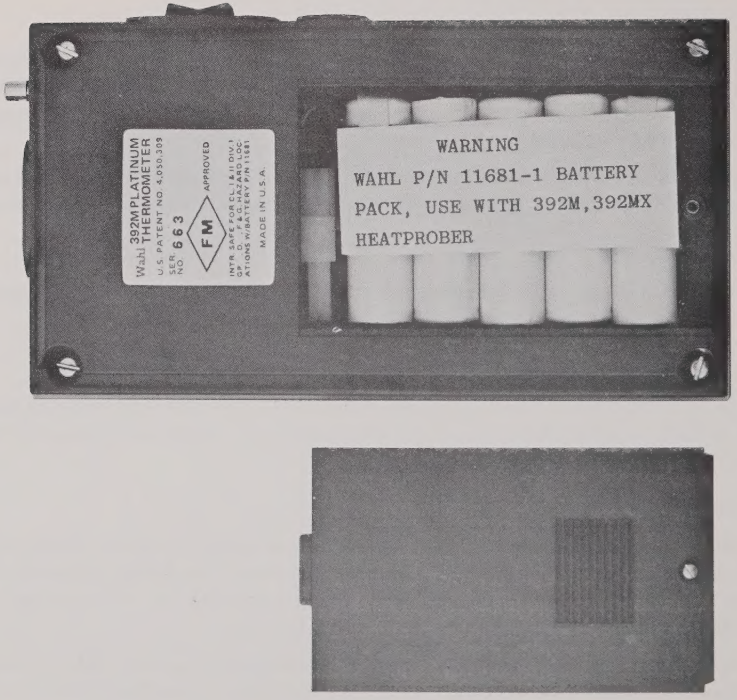

Figure 2-2. Rechargeable Battery Pack Compartment for 392M and 392MX.

SPECIAL NOTE: Rechargeable batteries should be kept at full charge. On the shelf, they will gradually discharge, losing about 10% charge per week. Ni-Cad's have the characteristic of losing their ability to be recharged to the top voltages if allowed to drop to discharge conditions for long periods. It is best to keep the batteries on recharge during non-use periods. If the battery fails to respond to recharge, provisions have been made for ease of replacement. Open the back cover, and disconnect from the instrument by means of the Molex connector. Replace with Wahl P/N 11681 (See Figure 2-2.).

2.4.1 Recharging

To recharge the batteries, use the recharger supplied. Plug in directly to 100v, 60 cycle wall plug and insert jack into socket on left side of HEAT-PROBER. (For overseas 220-volt lines, use a Franzus converter adapter with the recharger supplied or request a 220 volt recharger.)

2.4.2 Continuous Operation

The HEAT-PROBER can be continuously operated by using a battery recharger to restore or recharge the batteries as rapidly as they are depleted. The instrument operates from the batteries only, not from the recharger.

NOTE: The instrument cannot rectify AC current. A DC charger with open circuit voltage of 9.0 volts and approximately 120 milliamperes will maintain the battery charge. This occurs when the switch is on and the instrument is operating. Do not connect a voltage source to the batteries unless its current is limited to 120 milliamperes.

The MA-150 recharger will charge the batteries with the switch "OFF", or make-up battery drain if the instrument is operating. The recharger supplied with the instrument will enable continuous operation, depending on the number of digits being displayed. The recharger will make up a fixed drain up to 120 milliamperes. The instrument will normally draw 90 milliamperes but for a reading, for example, of 202.2°F, 115 milliamperes will be drawn, because of the configuration of the digits.

3.0 PROBES

The probes are made with a 100 ohm (Ro winding) in a 3-wire circuit in which a balancing resistor is added to adjust all probes to 101.0 ohms at 0°C. (See Figure 3-2).

3.1 Interchangeability

Each probe is individually "balanced" at 0°C to adjust for variance of resistances in the different configuration probes. This provides probes which are all interchangeable at 0°C within the accuracy statement before. In addition, each probe is tested at one higher temperature at least, and this data is recorded on a calibration tag (see Figure 3-1) attached to the probe.

	Probe Interchangeability (Immersion)
Ice Point	±0.3°C(±0.5°F)
100°C	±0.6°C (±1.0°F)
200°C	±1.1°C (±2.0°F)

Surface probes are tested on surface calibration plates especially built to replicate the end-use. The variance is somewhat larger as follows:

100°C	±1.1°C (±2.0°F)
200°C	±2.2°C (±4.0°F)

NOTE: Platinum sensor element manufacturers quote ±0.1% tolerance at 0°C, or ±0.1 ohms on a 100 ohm sensor. This results in ±0.3°C variance. The tolerance at higher temperature is **higher** than 0.1% in accordance with the following formula as specified by DIN 43760:

$$\text{Tolerance} = \pm .3°C + .0054t\ (°C)$$

Thus at 200°C, the expected sensor error could be 0.3C + .0054 (200) = ± 1.38°C.

Wahl
Quality Control
Test Certification
for DIGITAL HEAT-PROBER
Temperature Probe
Date Tested _____
This probe has been tested in a well-stirred ice bath for 0°C, and a well-stirred oil bath which is kept at 199± 0.5°F with a calibrated platinum probe and meter.
Surface probes are tested on a surface plate which is monitored by calibrated RTD surface probes and meter.
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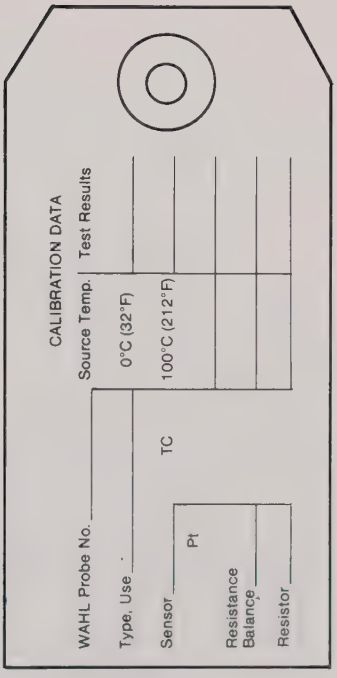


Figure 3-1. Wahl Calibration Tag.

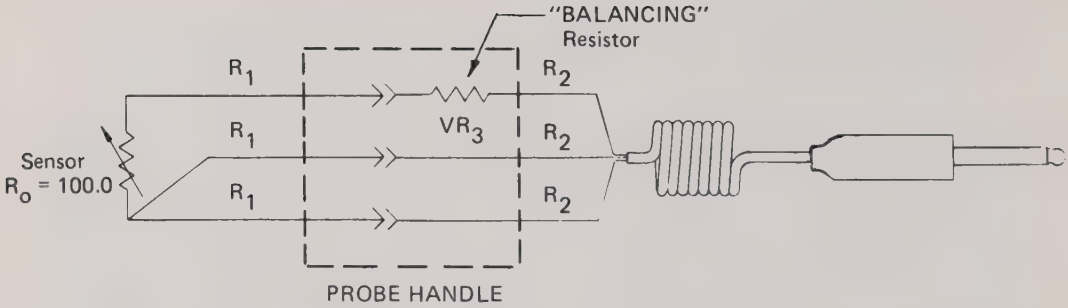


Figure 3-2. Probe Circuit

3.2 Temperature Sensors in Use

An understanding of heat-transfer is needed for accurate field use of temperature sensors. The sensor measures its own temperature, therefore, to measure a body temperature it requires good contact with that body, or in the case of liquids or gases good immersion and mixing.

A portable probe temperature sensor must have the following characteristics:

(a) a low thermal mass (product of its specific heat and weight);

(b) a large area for surface contact to permit heat-transfer between the object being measured and the probe sensor,

(c) a minimum of heat conduction away from the sensor which will reduce its temperature below that of the object being measured and create an inaccuracy.

The WAHL surface probes are designed with the above three conditions as criteria, and also include an insulating handle for your safety and convenience. Each probe is assembled with a plastic handle made of high quality Delrin which:

(a) Thermally isolates the hand from the probe, preventing hand heat from reaching the sensor, and sensor heat, in the case of a high temperature measurement, from burning the hand.

(b) Electrically isolating the hand from the metal probes and therefore, potentially, from a voltage on the surface to be measured.

The handle is attached to the tangle-free retractable cord which extends 4' and retracts to 12" (See Figure 2-1). Each probe is labeled with its part number and type.

For surface measurements, to obtain best time responses and accuracy, two things are necessary;

(a) Good surface contact with all of the probe surface. Make sure of this by holding it squarely on the surface. The 121 and 145 surface probes are specially designed with a spring loaded tip to provide compliance with the surface.

(b) A rough surface gives poor heat conductance to the measuring probe. This can be overcome by applying a thin layer of heat conducting silicone paste between the measuring point and the probe tip. The paste **shortens indicating time up to 50%.**

In liquids, move the immersion probe around and mix to get good contact. In air, put the probe in the vicinity of a stream to get good velocity, otherwise move the probe back and forth to induce velocity across the tip.

For the bolt-on or stick-on probe/sensors, it is recommended that an insulating layer of cement be placed over the unit after installation to prevent heat loss to the surroundings.

4.0 SPECIFICATIONS, Model 392M Platinum

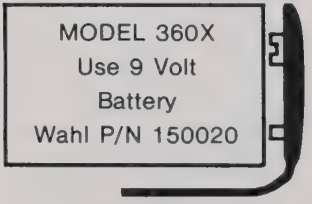
Temp. Measurement Range	−180°C to 788°C (−290°F to 1450°F)
Sensor Type	.00385 ohm/ohm/°C Platinum per IPTS−68 Tables or DIN No. 43760
Linearization	Micro computer corrected over entire range with 6,000 points and moving average, tracing IPTS−68 curve to ±.1°F.
Linearization	Micro computer corrected over entire range with 6,000 points and moving average, tracing IPTS−68 curve to ±.1°F.
Resolution	.1°C or .1°F from −180°C to 190°C (or −290°F to 375°F) —and— 1°C or 1°F from 190°C to 788°C (or 375°F to 1450°F
Update Rate	2.5 readings/sec.
Meter Accuracy @ 25°C	±1°F from −290 to 375°F and ±1°F from 375° to 1450°F
System Accuracy, with probe	±0.3°C at 0°C; ±0.5°C at 100°C
Repeatability	±1°F ±1 digit
Peak Hold (Holds Highest Reading)	Microcomputer Calculated - Switch to "P" to activate
F to C Conversion	Selected and installed during mfg. Optional switch selectable.
Environmental Temp. Range	−20 to 140°F (−28 to 60°C)
Temp. Coefficient	.02 deg/deg over Ambient Range of 0 to 120°F.
Display	0.3"high LED or 0.4" high LCD with automatic decimal point and polarity indication. Open probe display —OL—

Probe Connection	Switchcraft TT–253 mates, 3-wire coil-cord extensible to 4 feet.
Probe "Open" Indication	Open probe displays "OL" on display
Power Requirements	90 ma with 4 digits @ 5VDC
Batteries	Five pack, size AA rechargeable nickel cadmium batteries @ 6.25 v, removable from back cover.
Low Battery Indication	Low Battery displays "L" on display in most significant digit.
Recharger	7.5 v @ 120 ma from 110vac line supplied.
Line Operation	Continuously operable from recharger through internal batteries.
Battery Accessibility	Batteries removable from back cover with quick disconnect plug
Effects of High A/C voltage on Probe	— no shock or display effect to 110 vac — no damage to 500 vac
Probe interchangeability	All probes thermally matched to ±0.3°C at 0°C for interchangeability. (additional accuracy refinement option. Microcomputer corrected to within ±0.1°C at 0°C, and ±0.3°C at 100°C).
Size and Weight	3″ wide × 6″ long × 1-1/2″; 12 oz. (7.5cm × 15cm × 3.75cm) 340 gm.
Noise Rejection	Greater than 40 DB at 60 Hz increasing at 20 DB per decade. Spurious noise is attenuated by internal 16Hz filter, and computer generated moving average.
Options Available	See Section 8.0.

4.1 SPECIFICATIONS, Model 360X

Same as 392MX except:

Temp. Measurement Range:	−50.0° to 400°C −60.0° to 750°F
Resolution:	.1°C or .1°F from −50° to 190°C (or −60° to 375°F) — and — 1°C or 1°F from 190° to 400°C (or 375° to 750°F)
Recharger:	Not available.
Options:	None
Battery:	One 9.0 volt transister MN1604 Wahl P/N 150020



5.0 MAINTENANCE/REPAIR

The HEAT-PROBER instrument may be recalibrated, or adjusted for a particular probe in the field by following the directions in Section 6.0. However, it is recommended that calibrations and repair be done at the factory. Return the HEAT-PROBER in its foam package with a description of symptoms, and a repair estimate will be made for your approval.

The best way to check the functioning and calibration condition of the HEAT-PROBER is to use the Wahl accessory calibration P/N 10786, which plugs right into the probe connection and provides five key calibration points (See Figure 5-1). The calibrator has a set of precision-wound resistors which are measured at the factory against an NBS traceable standard. The WAHL calibrator is a convenient instrument to determine whether a problem is in the probe or the meter. If the meter checks on all 5 calibration points within reasonable tolerance, for example, then one will know that the probes are at fault.

The most common maintenance problem is battery failure, evidenced by no display. NiCad battery failure and prevention of this problem are noted in Section 2.4. If you suspect a dead battery:

1. Plug in the recharger and allow to recharge for 12 hours. If batteries fail to recharge after this time:

2. Open the battery compartment lid on the bottom of the instrument. Unplug the battery. Using a DVM, check the battery voltage with a 16 ohm load. If the voltage drops rapidly it indicates a fault in the battery.

3. With the convenient detachable plug, the battery pack P/N 11681 can be easily replaced by a new one. For emergencies it is possible to use a 9-volt transistor battery to power the HEAT-PROBER (but one must make a special connection). Expected continuous running time on 9-volt alkaline battery is about 3 hours, for LED display or 6 hours for LCD display.

LED Display

LCD Display

Figure 5-1. 392M Platinum Heat Prober with Wahl Calibrator P/N 10786

6.0 SET-UP AND CALIBRATION

6.1 Equipment Needed

A. Digital voltmeter, Fluke 4½ digit Model 8600A or equivalent.

B. Wahl Platinum Calibrator (P/N 10786) or General Radio decade resistance box, Model 1433-T with standard coilcord (P/N 10434) cable as used with Wahl probes.

C. Resistance versus Temperature Table, (Table I).

D. Power supply -- Powermate, Model OPA-10C or equivalent.

6.2 Voltage Regulator Adjustment (Note: Meters with serial numbers S/N 3445 and higher do not require adjustments of voltage regulator.)

Remove the 4 screws from the bottom of the case, then remove the top cover. You will note the adjustment points as shown in Figure 6-1.

1. Initially the 392M should be set-up with an external power supply (rather than a battery) so that the current can be limited to no more than 120 milliamperes.

2. Connect the plus (+) DVM lead to C-10 junction common with Q2. Connect the minus (—) lead to the cathode lead of CR1.

3. Apply power to the 392M using an external power supply with the voltage set at 6.5V and current limit set at 120 milliampers. Connect power supply (+) to U1-1 and (—) to CR1 - cathode.

   Adjust R21 for a voltage reading of exactly +5.000 volts on the DVM.

4. When the 392M has been mounted in its case and connected to a 5-battery pack, the DVM is connected as described above and the +5.000 adjustment checked and trimmed if necessary.

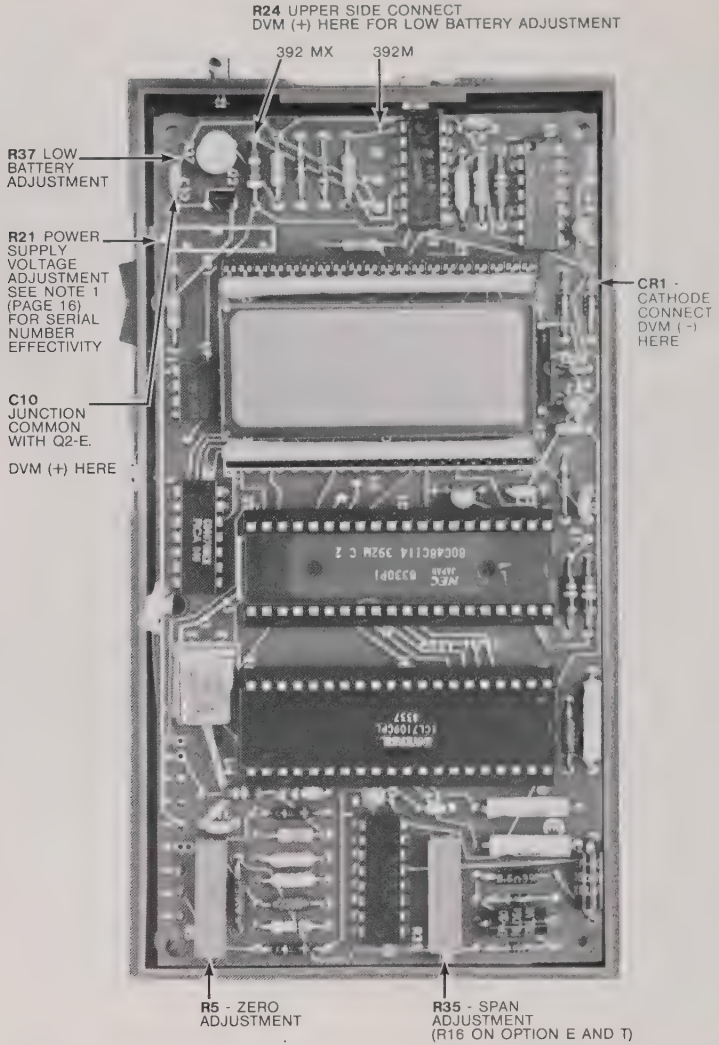

R24 UPPER SIDE CONNECT
DVM (+) HERE FOR LOW BATTERY ADJUSTMENT
392 MX
392M
R37 LOW BATTERY ADJUSTMENT
R21 POWER SUPPLY VOLTAGE ADJUSTMENT SEE NOTE 1 (PAGE 16) FOR SERIAL NUMBER EFFECTIVITY
C10 JUNCTION COMMON WITH Q2-E.
DVM (+) HERE
CR1 - CATHODE CONNECT DVM (-) HERE
R5 - ZERO ADJUSTMENT
R35 - SPAN ADJUSTMENT (R16 ON OPTION E AND T)

Figure 6-1. Calibration Points on 392M and MX

6.3 Low Battery Adjustment and Testing

1. Connect DVM (−) to CR1 Cathode and (+) to upper side of R24.
2. Adjust R37 clockwise or counterclockwise until DVM reads 2 volts.
3. Disconnect DVM.
4. DISCONNECT BATTERY PACK. Low battery indication test must be performed with an external variable power supply. Start with 6 volts and slowly decrease the voltage toward 5.8 volts.
   When the battery threshold is reached, a small "L" should appear in the most significant digit position of the 392MX display. The actual value of the low battery voltage threshold may vary from 5.45 volts to 5.55 volts.

6.4 Zero Adjustment Using Wahl Calibrator

1. Insert the Wahl calibrator and adjust the calibrator to the 32°F/0°C position. Apply power to the 392M and make an initial adjustment at R5 clockwise to increase reading and counter-clockwise to decrease the display reading. Adjust to 32°F or 0°C depending on your model.

NOTE: For the version 392MT, which has a 4-wire probe configuration, the microprocessor averaging process is slightly slower. The moving average for the 392MT may be made faster by turning the power off and then back on again, any time an input resistance or a pot setting is changed.

2. Make the best adjustment you can at this point, and then proceed to the span adjustment.

6.5 Span adjustment using Wahl Calibrator

1. Set Wahl Calibrator for 284°F/140°C and apply power to the 392M. Adjust R35 (R16 on option E and T.) clockwise to increase readings and counter-clockwise to decrease readings.

2. Repeat the zero and span adjustments until the 392M reads 32.0°F/0.0°C exactly, and reads 212°F/100°C or 284°F/140°C within acceptable limits of error.

   Since only one span adjustment covers both low and high scales, any error that must be tolerated should be pushed to the high scale where percentagewise it will be less of an error.

6.6 Adjustment Using Decade Resistance Box

Basic Theory: Platinum has a well defined resistance versus temperature curve. Accordingly, if a decade resistor is put in place of the probe to simulate the standard platinum element, a quick calibration can be made.

1. The decade resistor box may be used to make any point calibration. A coilcord cable with connector for the Wahl probe should be used (P/N 10434). This has a resistance of 0.3 ohms. The total resistance to be simulated is 1 ohm above the sensor resistance found in Table I. Therefore, the decade resistance setting should be a table value +1.0 ohm −0.3 ohm (for cable), i.e., add .7 to table values. At 0°C, the sensor will be 100.0 ohms from Table I, plus 1.0 ohm − 0.3. The decade setting should be 100.7 ohms.
2. Dial in 93.72 ohms on the decade box and adjust R5 for a display reading of 0.0 F or −17.8°C.
3. Dial in 285.01 ohms on the decade box and adjust R35 (Span) for 950 F or 510 C.
4. Repeat steps 2 and 3 until both readings are exact.
5. If the instrument is to be specifically set up at some other temperatures, step 2 remains the same for adjusting 32 F/0 C, but any other combination of resistance/temperature may be used to adjust span such as 212 F/100 C or 350 F/176.7 C.
6. Adjust decade box to 71.69 ohms and verify that the display indicates −100.0 F/−73.3°C within 0.3°F or 0.2°C.

6.7 Peak Hold Circuit

1. Apply power to the 392M through its power switch and put the switch in the forward position for Peak Hold mode. Adjust calibrator or decade box for an upscale temperature reading allowing the display to stabilize.

2. When display has stabilized to a temperature reading appropriate for the calibrator/decade box setting, move the calibrator/decade box to a position or resistance that represents a lower temperature, and verify that the peak temperature of step 1 is held.

   NOTE: This is a digital peak that is computed by the peak hold circuit, and as such will not drift up or down as may happen with analog microprocessor. What may happen is that the calibrator or decade box can momentarily "go open" as it is switched between settings. The computer may see this and jump up scale and retain a higher reading. When this happens, remember what the cause is and do not look to replace bad parts.

6.8 Fahrenheit to Centigrade Conversion

The HEAT-PROBER can be ordered as a °F or °C unit. The 392M will read out in °F unless a jumper is in place. When jumped the equivalent reading of what was displayed in °F will be displayed in °C. The computer makes the calculation and there is no adjustment.

6.9 Open Probe Display

Remove the calibrator or decade box from the 392M while the power is on. The display should show —OL—.

If power is turned on while probe is absent, the same display should occur.

6.9.1 "Help" Display (Appears on 392M only, 392MX does not display "Help")

The microcomputer is programmed to display "Help" when span adjustments outside the normal

range are attempted. If "Help" continues to be displayed, it indicates that an incorrect adjustment is being attempted or a faulty meter.

Keep decreasing the supply voltage until 5.5 volts is reached, as measured with a digital DVM. The 392M should maintain correct operation even though the small "L" is on, indicating a low battery.

Now raise the voltage back up until the small "L" turns off. The voltage at which this happens should be from 5.50 to 5.55 volts.

Under normal operation, an additional 20 minutes will elapse from the time the small "L" appears until the battery voltage decreases to 5.5 volts, assuming a normal 5-pack of AA NiCad batteries is being used. Below 5.5 volts, the computer may introduce some errors or not operate the display at all.

7.0 THERMAL CALIBRATION PROCEDURE

For thermal calibration of temperature, baths are needed for immersion probes, and surface plates are used for surface probes. However, remember that calibrating with a specific probe will introduce the error of the probe into the meter system. Other probes may therefore introduce greater or lesser error, because the meter is moved away from its nominal curve. DO NOT calibrate a surface probe by immersion. There will be an error because compensation is made at the factory for heat loss in surface probes.

Insert the probe in the unit and into well stirred, controlled ice baths at 0°C. (Be sure it is well stirred). The temperature can vary ±1°C, depending on the layer of water the probe is in, or proximity to a piece of ice.

With the top cover removed (as explained in p. 6.2) and instrument open, adjust until the 0.0 reading is obtained.

For span, a 250°C or higher bath, should be used. Adust R35 until the temperature reading is achieved.

It is not necessary to rejust zero after a span adjust.

8.0 392M OPTIONS

8.1 Noise Rejection Program (Order Option E)

This unit utilizes Revision A microprocessor with a program that takes moving averages of the input. Thus the readings of the minicycles are averaged to increase noise resistance. It features additional electronic filtering to improve operation in electronic noise. The meter response to temperature changes will be slower than the standard instrument.

8.2 Probe Matching Program (Order Option T)

In this version a special 4-pin receptacle is installed at the probe connection, and the four pins are wired to the printed circuit board from the probe connector side as shown in figure 8-1. The 5K resistor normally found at R33 is removed, and by way of the extra pin is installed in each individual probe. 5K resistance indicates to the microprocessor that nominal curve values in the memory shall be used. Other values of this resistor tell the microprocessor to initiate corrections to the nominal curve.

Close matching with a probe is achieved as follows: The probe is tested at a specific bath temperature, and a decade box is attached where the R33 resistor would be in the probe. The resistance is adjusted until the 392M reads the precise temperature of the bath, for example 100°C, taking out the tolerance of the probe. A value of 4K, for example, may be needed in the decade box to adjust the reading by 0.2%. The new resistor value of 4K tells the microprocessor to make an adjustment for that specific probe. The decade box is removed, and a resistor with the same value as the adjusted box is potted inside the 4-pin probe connector between pins 3 and 4 (see figure 8-2).

Each "T" version probe, therefore, has its specific resistor to indicate to the microprocessor the correction to be taken.

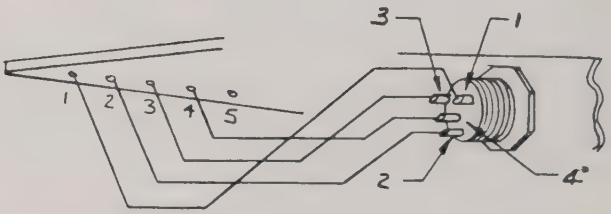


Figure 8-1. Wiring Diagram for Option "T"

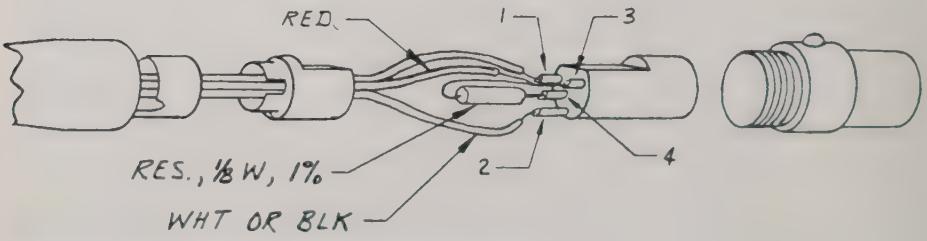


Figure 8-2. 4-Pin Probe Connector Expanded View

8.3 Degree F to Degree C Conversion (Order Option D)

The microprocessor provides true digital conversion for temperature throughout the whole range of the instrument. This switch is a convenience where dual measurement scales are needed.

8.4 Intrinsically Safe for Hazardous Operations (Order Option S)

The standard 392M instrument is Factory Mutual classified for Class I and II, Division I, Group D (for methane and propane), Group F (for coal dust), Group G (for grain dust). To achieve the higher level Group C rating (for ethylene gas), and Group E rating (for metal dust), the instrument is required to have an additional current limiting resistor in the NiCad battery pack. Therefore option S uses battery pack P/N 11681-2, which includes the current limiting resistor. In all other aspects, it is the same as the standard 392M.

8.5 Rate of Change with Hot and Cold Peak Hold (Order Option R)

This unit has microprocessor program revision E which can display any one of four different measurements repeatedly. The four display modes are as follows:

1. Normal Temperature. The temperature as sensed by the attached probe is displayed with updates 2.5 times per second. (Switch Position "N").
2. Rate of Change of Temperature. The change in temperature sensed is updated every six seconds. The rate of change is displayed in degrees per minute with proper polarity sign.
3. Hot Peak Hold. Continuous display of the hottest temperature sensed since the last time the unit was turned on. (Switch Position "HP").
4. Cold Peak Hold. Continuous display of the coldest temperature sensed since the last time the unit was turned on. (Switch Position "CP").

If either the cold peak or the hot peak should increase, the display will be updated to read the new colder or hotter peak. Turning the instrument off will remove the cold and hot peaks from memory. Upon turn on, the microprocessor is reset for the input of new data.

9.0 THEORY OF OPERATION

9.1 General

The microcomputer, as directed by this program receives and evaluates data from the analog-to-digital converter, and delivers the proper temperature values to the display driver. The readings may be in Fahrenheit or centigrade, peak or current value.

The flow chart (Figure 9.1) shows the operation of the program. Details of the components will be discussed in this section.

9.2 Program Flow

When power is turned on, the program will start executing instructions from address 000, the location of the top level program labeled "Main."

The first routine called is "Initialize". This is a house-keeping routine which establishes the starting conditions. The data memory (RAM) is cleared, the input/output ports are configured, and the display is set up for 0.0 reading.

Next, the routine "Gaincheck" is called. A solid state switch is confirmed to connect the A/D converter to a precision wire-wound resistor of known value. The resistor reading is compared with the ideal value, stored in memory, and a factor is calculated and stored to be applied to subsequent readings of the probe resistance.

Probe and gaincheck readings are maintained in a "Moving Average" (M.A.) fashion to minimize the effects of random variations. Gaincheck readings following "Initialize" or the detection of a removed

Main Program Platinum Heat Prober 392M

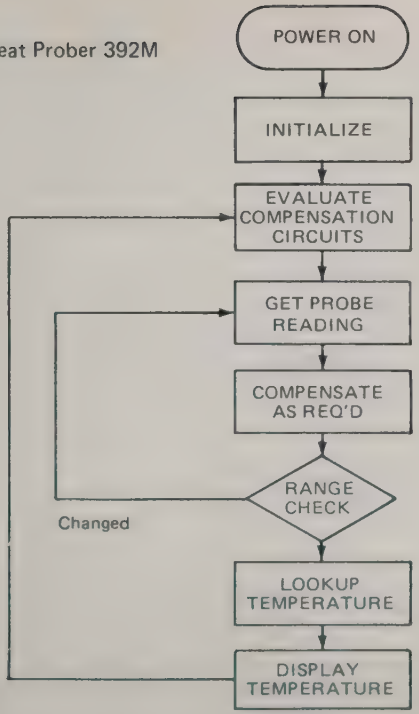


Figure 9.1 Flow Chart

probe cause the moving average to be crammed with the current value. Subsequent passes cause the moving average to be updated and refined. Gaincheck updates occur alternately with probe readings the first 15 cycles, and then they are performed only every 20th cycle. This is to allow more computer visibility to the probe updates with reduced inertia. Settling time is provided to allow analog reference circuits to stabilize when the probe readings are done on the high scale. The compensation readings are always done on the low scale. If readings exceed the compensation limits (about 6% is allowed), the program branches to a subroutine which displays "Help" on the second such excess.

The next routine entered, "Get Probe", performs as described above for the compensation readings; however a separate moving average is maintained for the probe readings. Both use a common subroutine, "Get M.A.", which calls "Get A/D". Control and handshaking between the converter and the computer is performed by this latter subroutine. Data is fetched in 2 bytes, first the low order 8 bits, then the high order 4 bits, the sign and overrange bits. "Get M.A." uses the converter reading to either cram or update, as directed by a counter within the computer.

The program then enters "Compensate". The factor derived from "Gaincheck" is added to or subtracted from the latest reading.

"Range" then examines the compensated answers to see if we are on the correct scale. The unit always comes up in the low range and remains there unless there is an overrange indication which causes the range to be changed to high. If a negative reading exceeds that which would be lower than −300 degrees, the routine branches to give an overrange display indication. If the unit is in the high range, and overrange is indicated (above 1500 F), the overrange condition is displayed (-OL-). If the reading is lower than about 370 degrees, the unit downranges. Any of these conditions cause the program to return to get a new probe reading with instructions that the moving average be crammed with new data. Additionally, if overrange is displayed indicating an open probe lead or removed probe, conditions are set up for the next entry into "Gaincheck" to cause the compensation

readings to be crammed; and also that rapid updates to it are to be made on following passes. This is done to accommodate changes in probes by the user, so that the display will represent the actual probe readings as soon as possible.

If no change to the current range is indicated, a fall-through occurs to "Get Temp". This routine essentially looks up the Fahrenheit temperature from tables. There are separate tables for each range.

The "Display" routine updates the display on every other trip through to limit possible rapid changes when the probe moving average is being updated in the fast mode. The answer to be displayed is converted to decimal, and then transmitted to the display driver in the order of most significant digit first. Leading zeros are suppressed up to the unit's digit. The decimal point is suppressed if the routine is called for the purpose of displaying "Overrange" or "Help".

The program is now complete and a jump to "Gaincheck" completes the loop.

10.0 392M TROUBLE-SHOOTING AID

10.1 Scope

This section describes basic diagnostics to find the majority of the problems with malfunctioning 392M units.
Equipment Required:

1. Wahl 392M Calibrator (P/N 10786)
2. 4-1/2 Digit DVM, Fluke 8600A or equivalent.
3. Tektronix Scope, 465 or T935.
4. Power supply, Power/mate BPA-10c or equivalent.

10.2 Procedure

Make certain that the 392M unit experiencing the problem has been properly set-up, or at least an attempt has been made as outlined in the Set-Up Procedure, Section 6.0, before proceeding to this section.

HOW TO USE TROUBLE-SHOOTING PROCEDURE: Locate the problem on this table and proceed with the action starting with Step 1. Note, for all DVM and scope measurements, connect the (−) lead to CR1 Cathode (GND).

TROUBLE SHOOTING PROCEDURE				
STEP	PROBLEM	ACTION TO BE PERFORMED	IF CORRECT	IF INCORRECT
1.	Blank Display	Measure voltage at Z6-19 with DVM. It should be at +4.3 ± .2v with (+) at Z6-19.	Go to Step 3.	Go to Step 2.
2.		Repeat above measurement, but with (+) at Q4 emitter.	Open trace between Q4 emitter and Z6-19.	Go to Step 4.
3.		Check Z4-25 with a scope. It should be a 3.58 MHZ "square wave" with levels from 0 to 5 volts. Put scope ground clip to CR1 cathode (GND). Use a 10X probe. Waveform will not be perfectly square, but will have rounded edges.	Replace Z6 and go to Step 9.	Replace Z4 and go to Step 7.
4.		Measure voltage at Q4 collector. It should equal the battery voltage or the applied voltage from a test power supply.	Go to Step 5.	Check for open traces between Pin 5 of harness and Q4 collector.
5.		Check voltage on both sides of R30 with DVM (+). The R30 side connected to CR5 cathode should be +5.000 ± .005 volts.	Go to Step 6.	Check for open traces from +5 line to R30.

TROUBLE SHOOTING PROCEDURE				
STEP	PROBLEM	ACTION TO BE PERFORMED	IF CORRECT	IF INCORRECT
6.		Check the R30 side connected to Q4 base. It should measure between 4.7 and 4.9 volts.	Replace Q4.	Replace R30.
7		Check Z4-25 again with scope as in Step 3. The 3.58 MHZ aquare should be present.	Display should be working.	If 3.58 MHZ not present go to Step 10.
8		Replace Z6 and check display for proper operation.	Done	Send to Factory technician.
9		If display still won't work.	Send to Factory.	Send to Factory.
10.		If still no 3.58 MHZ at Z4-25, replace Y1 crystal.	Done	Go to Step 9.
11	Cannot Adjust +5.000 volts.	Use DVM and measure voltage at U2-2. It should be 2.5 ± .1 volts. DVM (+) to U2-2. DVM (–) to CR1 Cathode.	Go to Step 14.	Go to Step 12.
12		Measure voltage at Pin 5 of harness DVM (+) to Pin 6 of harness. It should equal the battery voltage or the applied voltage from power supply.	Replace Z7 and go to Step 24.	Check harness wiring to schematic.
13		If +5 still cannot be adjusted, send to Factory.		–
14	*	Adjust R21 clockwise at least 21 turns and go to Step 15.		
15	*	Remove power for this measurement. Put meter on Ohms, automatic and measure from U2-3 to CR1 cathode (–). The reading should read from 1.3 to 2.1K.	Go to Step 16.	If resistance was greater than 2.1K, replace R21. If less than 1.0K, replace R22 and go to Step 18.

TROUBLE SHOOTING PROCEDURE				
STEP	PROBLEM	ACTION TO BE PERFORMED	IF CORRECT	IF INCORRECT
16.	*	Remove power for this measurement. Adjust R21 at least 21 turns counter-clockwise. Measure ohms from U2-3 to CR1 cathode (—). Measurement should be between 1.5K and 3.1K.	Go to Step 17.	Replace R21.
17.		Check for proper 2N4126 at Q2 location.	Go to Step 19.	Replace with 2N4126. If still cannot be adjusted go to Step 13.
18.		If problem still exists, go to Step 17.	—	—
19.		With power off, measure ohms from Q2 collector to CR1 cathode. The resistance should be greater than 125 ohms.	Go to Step 20.	Go to Step 13. Low impedance load connected to +5.00 line.
20.		Replace CR3 and try again to adjust +5.	Done	Go to Step 21.
21.		Replace CR4 and try again to adjust +5.	Done	Go to Step 22.
22.		Lift one end of R19 and measure ohms. It should read between 900 and 1100 ohms.	Resolder R19 and Go to Step 13.	Replace with a measured 1K resistor. Go to Step 23.
23.		Try to adjust +5 again. If it still cannot be done, go to Step 13.	—	—
24.		Measure voltage at U2-2. It should be +2.5 ± .1 volts.	Attempt to adjust +5 volts again. If you cannot, go to step 14.	Go to Step 13.

* NOTE – NOT APPLICABLE FOR SERIAL NUMBER GREATER THAN S/N 3445.

TROUBLE SHOOTING PROCEDURE				
STEP	PROBLEM	ACTION TO BE PERFORMED	IF CORRECT	IF INCORRECT
25.	Unit Constantly Reads - OL-.	Use the DVM and measure volts on Automatic scale. Put (+) lead to C8 (—) and the (—) lead to CR1 cathode (GND). The voltage should be $-4.2 \pm .1$ volts with +6 volts applied to the 392M by an outside power supply.	Go to Step 26.	Go to Step 28.
26		Set the Wahl Calibrator on 212^{O}F and insert into harness jack. Use DVM and measure the following voltages on the 2v scale without "Automatic".		
		Z3-12 should be .255 to .275v	Proceed to next Measurement.	Go to Step 27.
		Z3-13 should be .071 to .079v	Proceed to next Measurement.	Go to Step 27.
		Z3-1 should be .580 to .620v	Proceed to next Measurement.	Go to Step 27.
		Z3-3 should be .660 to .710v	Proceed to next Measurement.	Go to Step 27.
		Z3-14 should be .071 to .079v	Proceed to next Measurement.	Go to Step 27.
		Z3-4 should be .660 to .710v	Proceed to next Measurement.	Replace Z3.
		Z3-15 should be .580 to .620v	Proceed to next Measurement.	Replace Z3 and go to Step 31.
		Go to Step 29.		

TROUBLE SHOOTING PROCEDURE				
STEP	PROBLEM	ACTION TO BE PERFORMED	IF CORRECT	IF INCORRECT
27.		Return to Factory.	–	–
28.		Check for solder bridge at C6.	Go to Step 29.	Remove bridge and try again.
29.		Check the output of Z1-4 for a 0 to 6v square wave of about 10,000 cycles, ±2000 cycles.	Go to Step 30.	Go to Step 33.
30.		Replace CR1 and CR2 and try again.	Done	Replace Z4, and go to Step 32.
31.		Save the Z3 that was replaced and go to Step 27.	–	–
32.		If still reads –OL–, save the removed Z4 and go to step 27.	–	–
33.		Use DVM and measure for battery voltage at Z1-14. It should equal that seen at harness pin 5.	Go to Step 34.	Check for open traces from VBAT line to Z1-14. If problem cannot be found, go to Step 27.
34.		Use DVM and measure for ohms at Z1-7 to CR1 cathode (GND) Put on 200 ohm range and turn power off. The DVM should display less than 1 ohm.	Go to Step 35	Check for open traces leading from Z1-7 to CR1 cathode or cold solder joint. If problem cannot be found, go to step 27.
35.		Replace R18 and check for 10,000 cycle output at Z1-4.	Done	Go to Step 36

TROUBLE SHOOTING PROCEDURE				
STEP	PROBLEM	ACTION TO BE PERFORMED	IF CORRECT	IF INCORRECT
36		Replace C6 and check for 10,000 cycle output at Z1-4.	Done	Go to Step 37.
37.		Replace Z1 and check for 10,000 cycle output at Z1-4.	Done	Go to Step 27.
38.	Unit reads out of specification in	Replace Z3-(MC14043) (Multiplexer) and rerun.	Done	Go to Step 39.
39		Replace Z4 (ICL7109) (A/D Conv.) and rerun.	Done	Return to Factory.

11.0 ACCESSORIES

Safety Strap, DA-10 ..... $ 5.00

Silicone Paste, DA-4 ..... $ 3.00

Battery Recharger fixed output, 120 MA, 120v, 60 cycle (Replaces standard unit) MA 150 ..... $20.00

Battery Recharger, 220v, 50/60cycle, European Connection, MA150E $20.00

Instrument Kit Case, holds meter, recharger, 2 probes, calibrator, in urethane foam, DA-60 ..... $50.00

Extra batteries. AA, nickel-cadmium (5) P/N 11681-1, with connector... $30.00

Intrinsically safe battery pack, AA, nickel-cadmium (5) PN 11681-2 with fusible resistor $40.00

Carrying Case, for meter, hand strap and belt clip MA-6 ..... $15.00

Calibrator, 5-points, plugs into probe connector, NBS Traceable P/N 10786 ..... $99.00

12.0 CALIBRATION SERVICE

Recalibration service can be provided at a nominal cost of $30.00, if desired. Special thermal calibration traceable to NBS is $90.00 for these temperature points, 0°C, 94°C, and 250°C for immersion probes, and two points for surface probes, 100°C and 200°C.

Table 1

INTERNATIONAL RESISTANCE VS TEMPERATURE — IPTS-68, DIN43760
(For .00385 Ohm/Ohm/°C Platinum)

DEGREES C	0	-10	-20	-30	-40	-50	-60	-70	-80	-90	-100
0	100.0	96.09	92.16	88.23	84.29	80.32	76.34	72.35	68.34	64.32	60.28
DEGREES C	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
0	100.00	103.90	107.79	111.67	115.54	119.40	123.24	127.07	130.89	134.70	138.50
100	138.50	142.29	146.06	149.82	153.57	157.31	161.04	164.76	168.46	172.16	175.83
200	175.83	179.50	183.16	186.82	190.45	194.07	197.69	201.29	204.88	208.46	212.02
300	212.02	215.58	219.12	222.66	226.18	229.69	233.19	236.68	240.16	243.61	247.08
400	247.08	250.52	253.95	257.37	260.77	264.17	267.56	270.94	274.29	277.64	280.98
500	280.98	284.31	287.63	290.93	294.22	297.50	300.76	304.02	307.27	310.51	313.72

TOLERANCE (Probe Interchangeability)

Temperature (°C)		-250	-220	-200	-100	0	100	200	300	400	500
Tolerance	(±°C)	5.8	1.8	1.2	0.7	0.3	0.5	1.1	1.7	2.3	3.0
	(±Ω)	1.0	0.7	0.5	0.3	0.1	0.2	0.4	0.6	0.8	1.0

DEGREES F	0	-20	-40	-60	-80	-100	-120	-140	-160	-180	-200
0	93.03	88.65	84.26	79.85	75.42	70.98	66.52	62.04	57.54		

DEGREES F	0	20	40	60	80	100	120	140	160	180	200
0	93.03	97.39	101.74	106.07	110.38	114.68	118.97	123.24	127.50	131.74	135.97
200	135.97	140.18	144.38	148.57	152.74	156.90	161.04	165.17	169.28	173.38	177.47
400	177.47	181.54	185.60	189.64	193.67	197.69	201.69	205.68	209.65	213.61	217.55
600	217.55	221.49	225.40	229.31	233.20	237.07	240.93	244.78	248.61	252.43	256.23
800	256.23	260.02	263.80	267.56	271.31	275.04	278.76	282.46	286.15	289.83	293.49

TOLERANCE (Probe Interchangeability)

Temperature (^{O}F)		-420	-400	-350	-300	-200	-100	0	32	100	200	300	400	500	600	700	800	900
Tolerance	($\pm^{O}$F)	10.4	8.3	3.3	1.9	1.5	1.1	0.7	0.6	0.7	0.9	1.5	2.0	2.7	3.3	3.9	4.5	5.4
	($\pm\Omega$)	1.0	0.9	0.7	0.5	0.4	0.3	0.2	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.8	0.9	1.0

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